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SURVEY OF THE LARCH SAWFLY IN THE LAKE STATES - 1950

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- 1950 -

INTRODUCTION

In a preceding Administrative Report (Butcher and Eaton (1949)) an attempt was made to summarize build-up of the larch sawfly (Pristiphora erichsonii (Htg.)) during the period between 1940 and 1949. A brief historical review of previous outbreaks and the potential for destruction by this species prefaces the review of incidence and injury presented therein.

The material to be presented here constitutes an expansion of survey activities initiated in 1949 and is one phase of an over-all program designed to make information available on the extent and progress of the current epidemic, along with recommendations as to how depredations by this insect might be minimized.

Information contained in this report was compiled by personnel of the Milwaukee Forest Insect Laboratory. The survey in Minnesota and Wisconsin was conducted by the author with the assistance of James C. Feigal and Stanley A. Gruetzman. Data for Michigan was obtained by D. M. Benjamin, assisted by Louis Grapp. Maps were supplied by the U. S. Forest Service and the Lake States Forest Experiment Station. The Chippewa National Forest provided facilities for field headquarters maintained at Cass Lake, and the staffs of both the Chippewa and Superior National Forests cooperated fully in completing the survey. Minnesota Conservation Commission officials and personnel of the St. Louis County Land Commissioner's office also extended assistance whenever it was requested. Dr. A. C. Hodson of the Division of Entomology, University of Minnesota, contributed specific reports of defoliation which are integrated with those of the author.

METHODS AND PROCEDURE

Whereas in 1949, personnel and time limitations necessitated employment of aerial reconnaissance as the chief survey instrument, in 1950 this was used only as an accessory technique. The accumulated information herein presented on distribution of the epidemic was obtained by means of the following methods: (1) roadside plots, (2) roadside reconnaissance, and (3) aerial reconnaissance.

A total of 36 roadside plots were established as follows: 23 in Minnesota (chiefly on the Superior and Chippewa National Forests); 4 in northern Wisconsin; and an aggregate of 9 in Upper and Lower Michigan. Increment borings, defoliation estimates, cocoon samplings and other data were obtained from a random cruise into each stand to a depth of approximately two chains. Stands less than 10 acres in size were not used as permanent plots unless it was impossible to find larger ones. Where defoliation was appreciable (1 percent or over) a minimum of 1-1/2 man hours per plot was spent in cocoon sampling for subsequent correlation of these data with defoliation estimates. These points are designated by solid triangular markings in Figure 2. Where estimated defoliation (based on a random selection of 10 trees per plot) was less than 1 percent, no cocoon sampling was

was attempted. (See solid rectangular markings - Figure 2). In such situations, e. g. where only occasional twigs showed defoliation, the extreme bias necessary to find any cocoons made it appear unlikely that the data so obtained would lend itself to correlation with data procured by random sampling of plots showing higher percent defoliation. In only one plot at Brule, Wisconsin was this arbitrary lower limit invoked. Throughout the remainder of the plots percent defoliation either exceeded this figure or defoliation caused by this insect was not present at all and cocoon samplings were not indicated.

In addition to the information on defoliation and cocoon sampling already referred to, systematic notations on other stand characteristics were recorded for each plot. These observations included (1) date, (2) observer, (3) stand density, (4) location, (5) approximate acreage and (6) an estimate of stand composition. The following information was recorded for each of 10 trees selected at random from each stand: (1) DBH, (2) total height, (3) crown height, (4) percent defoliation, (5 - 6) presence of bark beetle or borer injury, (7) percent of soil surface (within crown circumference) under water, and (8) the extent of oviposition injury (whether light, medium or heavy) for both 1949 and 1950. Supplementary notes on herbaceous and woody undergrowth were included along with references to topographic features. A copy of the survey sheet is included in the Appendix.

Roadside observations, made concurrent with establishment of the plots, generally confirmed impressions of population size which were forthcoming from the respective plots. These estimates were recorded in most cases while travelling from one plot to another, and no information other than defoliation was sought.

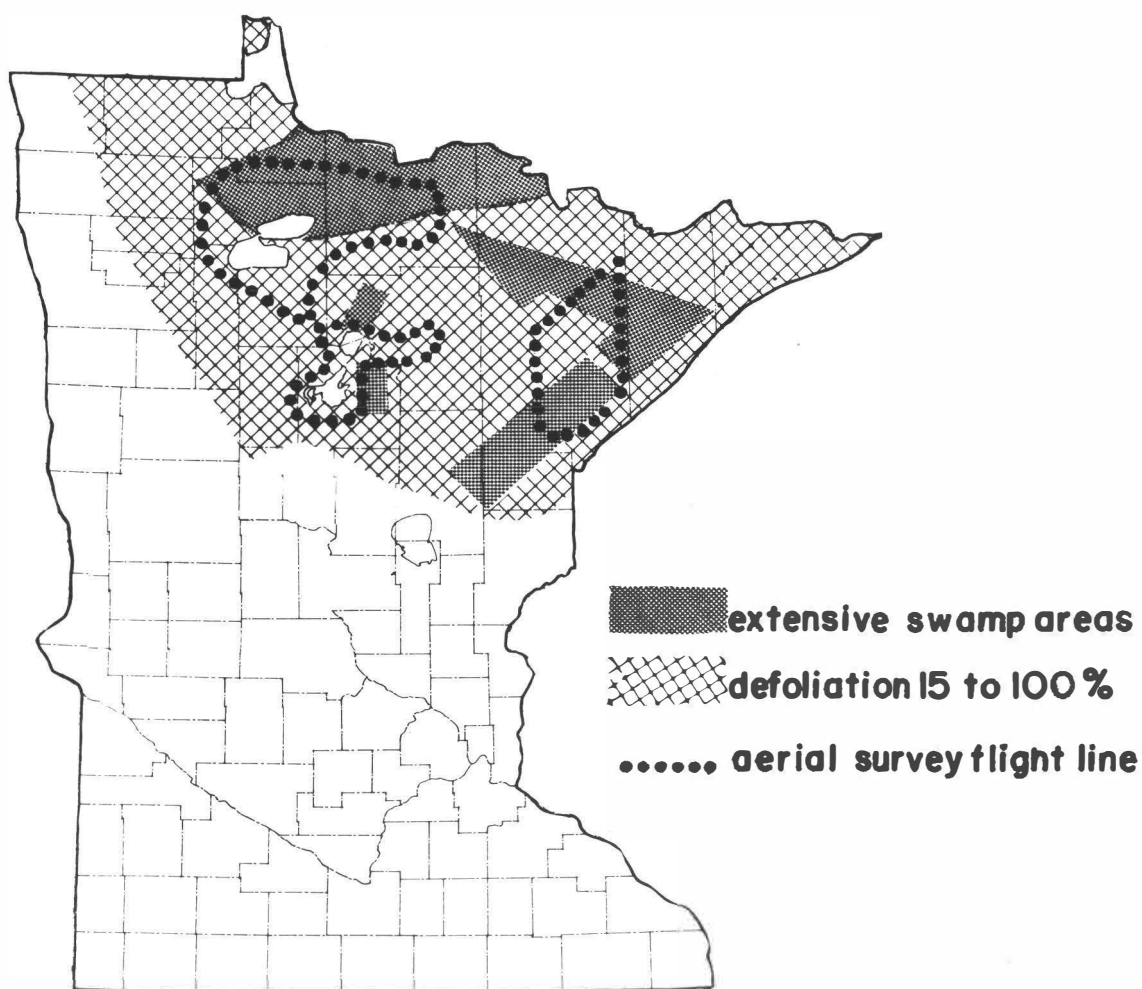
Aerial reconnaissance was employed chiefly to confirm the accuracy of population estimates obtained from the foregoing techniques. This procedure permitted a synthesis of many impressions into a coherent pattern. All aerial reconnaissance conducted was carried out with emphasis on the Chippewa and Superior National Forest areas. A total of 5 hours and 40 minutes was spent on two flights over the Chippewa, proceeding according to flight lines on the accompanying map (Figure 1). The relatively inaccessible areas along the Canadian border from International Falls west to Warroad were reconnoitered in this manner for the first time. On the Superior National Forest only one flight was made (see map) lasting 1-2/3 hours, proceeding from Ely southward toward Duluth and return.

Conduct of aerial reconnaissance differed little from the method used in 1949. Since there was more time for ground surveys, however, it was possible to forego detailed mapping from the air. This made it practicable for all necessary flying to be accomplished in a short time at a minimum financial outlay. An observer and a mapper accompanied the pilot as in 1949. For the most part flights were made at 2000 feet, which permitted visibility over a 10 - 15 mile stretch on either side of the plane. Since heavy sawfly defoliation is discernible at such an altitude and distance on clear days, it is calculated that roughly 6-1/2 million acres were observed in the course of the 7 hours and 20 minutes which were devoted to this work. These figures are derived on the basis of an estimated scanning range of 20 miles - 10 miles on either side of the plane - as follows:

FIGURE 1

EXTENSIVE SWAMP AREAS - FLIGHT LINES -

LIMITS OF APPRECIABLE DEFOLIATION



640 (MPH X FT X SR)

640 = acres per square mile
MPH = miles per hour air speed
FT = flying time
SR = scanning range

$640 \times 70 \times 7.33 \times 20 = 6,567,680$ acres observed

Since the area encompassing sawfly activity does not exceed 15,000,000 acres at the present time, it is felt that this represents a substantial sample of the infested tamarack in the Lake States.

INFESTATION PATTERNS

Some reference was made in the survey report on this insect for 1949 to the variability of tamarack type. Local inconsistencies in the infestation pattern are of such frequent occurrence as to warrant some acknowledgement of a possible dependent relationship between certain stand characteristics and the applicability of infestation criteria. Throughout northern Minnesota, where appreciable defoliation is evident, the tamarack types might arbitrarily be subdivided into pure and mixed stands. Both of these may be found in terrain characterized as rolling, and to a lesser extent in flat. The distinction between rolling and flat is largely one of convenience, since it is impractical for the purposes of this report to further delimit either category. The infested area lends itself to such a coarse differentiation by virtue of a relative concentration of either category into certain regions. The foregoing map (Figure 1) adapted from a Forest Distribution Map (prepared by the Forest survey staff 1939 - 1940) roughly delineates the major low-lying or flat areas (designated extensive swamp areas - Fig. 1). The remainder of the State might be characterized as rolling. Tamarack, where present in the flat terrain, frequently occurs as a pure stand; exceptions being where portions are sufficiently elevated or are otherwise dry enough to permit establishment of other tree species - chiefly black spruce. For the most part the interiors of these large swamps are either treeless or possess seedlings only, the trees becoming larger and more thrifty towards the periphery. It is only on the relatively dry periphery that other tree species become established.

Not all of the low-lying or flat area so designated on Figure 1 are of this type. On the north end of the Aurora and Two Harbors Districts of the Superior National Forest, for example, the tamarack is interspersed as fingers or stringers through stands of other species. Under these conditions, trees are of a more uniform height, and infestations by the sawfly are uniformly heavy, as contrasted to a fringe defoliation effect which the larger swamps exhibit upon examination from the air.

As a rule, the shaded areas in Figure 1 contain tamarack stands of one or both of the foregoing types. In the large swamps, extremely wet interiors presumably limit sawfly build-up either directly, through deleterious effects upon the overwintering pre-pupae, or indirectly by retarding

growth of the shoots and/or foliage; the latter thereby resulting in restricted oviposition sites and a reduced larval food supply, respectively. Attacks may be quite severe on the periphery of these swamps where water levels are not as high for as long a period each year. Presumably these trees are better able to support substantial sawfly populations and the result is defoliation which diminishes in intensity from the outer circumference to the center. There is no questioning this pattern since it is of such common occurrence. Where tamarack occurs as stringers, infestations are generally of uniform severity throughout the length and breadth of the stands, except for places where a wide flowage creates conditions similar to the interiors of the larger bogs discussed earlier. For the most part, these stringers are fringed by black spruce in the areas under discussion.

The cross-hatched portion of the infested area represents those sections of the State where tamarack occurs in relatively small pockets, sometimes pure, more often mixed; a consequence of a more rolling terrain. Here again defoliation is more nearly uniform throughout the stand when it occurs. It is in these situations and in those where the species occurs in stringers that most severe defoliation has been noted, both in 1949 and in 1950. As of 1950 these sites contain the high risk stands from the standpoint of sawfly damage. The significance of mixed as opposed to pure stands in relation to susceptibility would thus appear obvious. Species less tolerant of water than tamarack would be expected to occur only on the drier segments of swamp areas. Invariably, when the sawfly is present at all, defoliation is most severe in tamarack present in these mixtures. If other tree species occur at all one can postulate that even in very wet seasons the site may be dry enough to permit survival of overwintering sawflies in the soil where few might survive in many of the pure stands. Nor would one expect population fluctuations from year to year to be as great in the former as in the latter. Some data is on hand with which to substantiate this reasoning, and it will be incorporated in a subsequent report on research activities.

It is essential that acknowledgement be made of some of the foregoing factors in recognition of the circumstance that local topography can make a particular infested stand atypical of the area infestation level. Keeping in mind these suggested reservations, the results which follow can be considered representative of the infestation as it exists in 1950.

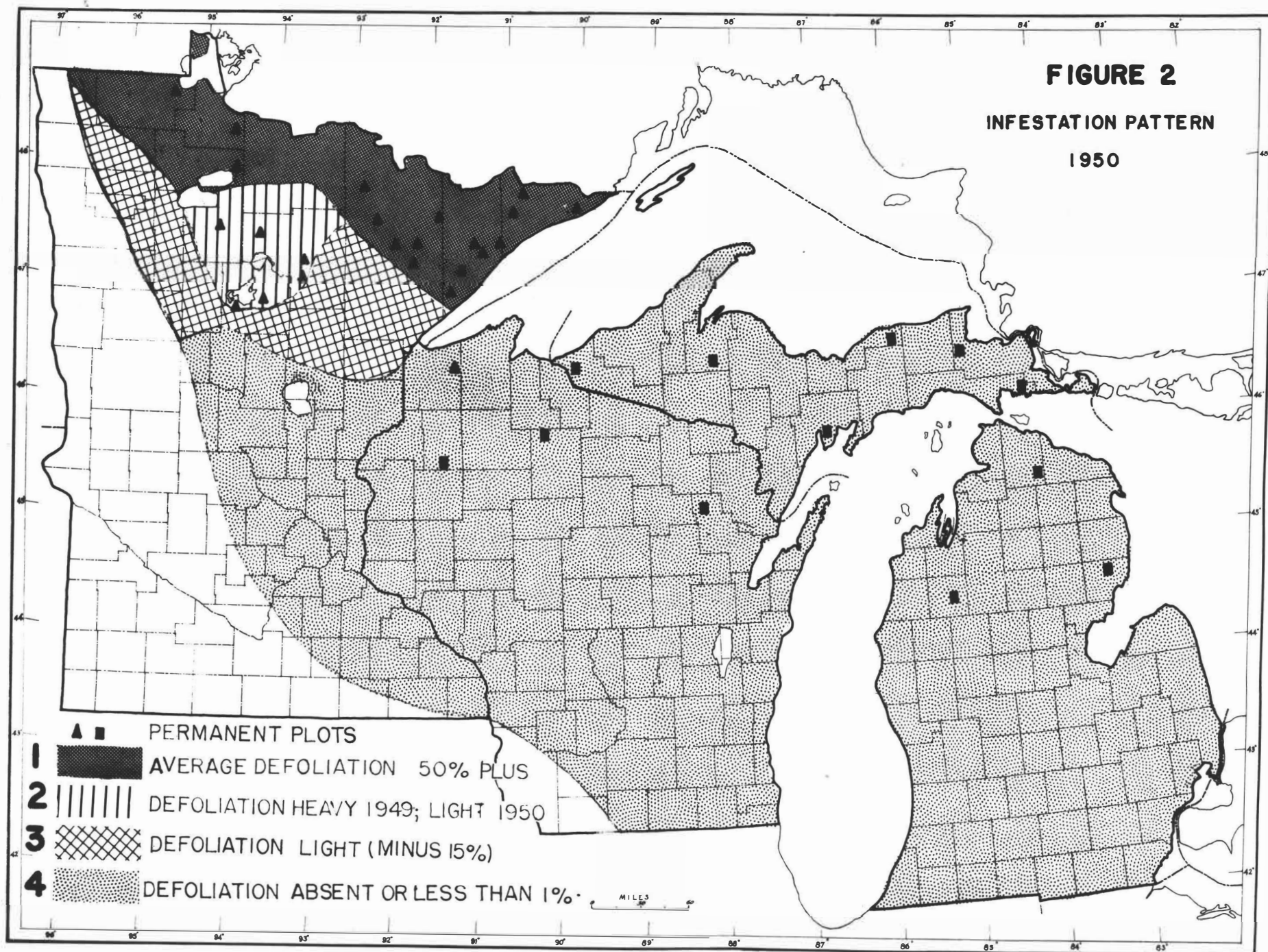
RESULTS

Figure 2 illustrates the infestation pattern derived from surveys conducted in 1950. Of 21 Minnesota counties where tamarack occurred and defoliation was appreciable, only 9 contained average defoliation of 50 percent or more. In the remainder of these, estimated defoliation averaged less than 15 percent. Exclusive of these 21 counties in northern Minnesota, defoliation of tamarack was negligible throughout the Lake States (less than 1 percent average). Evidence of sawfly work was picked up in only one of the plots established in Wisconsin (Brule), but not at all in Upper or Lower Michigan. On the other hand, roadside observations by personnel of the Forest Insect Laboratory indicate its presence on individual trees around Park Falls, Wisconsin and at Merriweather, Michigan; and Dr. R. D. Shenefelt reports its presence in small numbers at Griffith State Nursery in Wisconsin.

FIGURE 2

INFESTATION PATTERN

1950



Of particular interest is the recession of sawfly activity in 1950 in the Chippewa National Forest area. In 1949 numerous small stands and the fringes of larger bogs showed heavy defoliation (50 percent plus). In 1950 none of the pure stands was even moderately defoliated; heavy defoliation being confined to relatively small mixed stands. In a few instances defoliation in these stands was as high as 100 percent, but these represent only a small percentage of the tamarack on the Forest. On the whole, Areas 2 and 3 (Figure 2) possessed comparable defoliation in 1950, whereas in 1949 tamarack in Area 2 sustained defoliation comparable to 1950 defoliation in Area 1. Area 3 infestations seem to have remained static over the 1949-50 period, as has Area 1, with the possible exception of Roseau, Lake of the Woods, Beltrami and northern Koochiching Counties for which satisfactory records were not available in 1949. The mean percent defoliation, as obtained from plot records for Areas 1 and 2 in 1950, is as follows:

	: : No. Observations	: : Mean Defoliation (Percent)	: : S E
Area No. 1	: 17	: 58.9	: ± 7.85
Area No. 2	: 6	: 5.0	: ± 0.73

Some idea of the scope of the infestation in the National Forest area at the present time will be forthcoming from examination of Table 1. Here the total tamarack acreage by counties is listed, along with a tabular breakdown of estimated acreage falling within the 4 defoliation levels typified by zones 1 - 4 in Figure 2. Only counties within or adjacent to the Chippewa and Superior National Forest areas are represented. The figures upon which these estimates are based are not uniformly reliable, but they do serve to convey some idea of the magnitude of the problem. Unfortunately, however, a breakdown such as this fails to emphasize the scattered distribution of tamarack in northern Minnesota. It should be remembered that tamarack occurring as a minor component in mixed stands is not represented here at all, and any impression that the species is limited in its distribution to discrete areas is an unintentional product of an arbitrary type classification. It is also important to remember that minor component tamarack is often thrifty, and generally found in terrain where periodic flooding is unlikely to affect the sawfly adversely. From this it would appear that tamarack, where it occurs as a minor component, may constitute one of the chief obstacles to successful direct control of the sawfly since such stands can provide reservoirs of the insect from which subsequent re-infestation of treated areas might take place. The figures presented here do not suggest any of the foregoing implications, nor do they convey any information on the quality of the stands.

Of some 434,120 acres herein represented, 224,521 acres are in zone 1 (average defoliation 50 percent), 86,584 and 79,499 in zones 2 and 3 respectively (average defoliation less than 15 percent), and 43,516 acres in zone 4 (average defoliation less than 1 percent).

TABLE 1

TAMARACK TYPE AND LARCH SAWFLY INFESTED AREAS ON THE CHIPPEWA AND SUPERIOR NATIONAL FORESTS
AND ADJACENT LANDS

County	Type*	Estimated Acreage of Tamarack Type in Infestation Zones (Numbers correspond to zones in Fig. 2)				Source of Information
		1	2	3	4	
		:	:	:	:	
Lake of the Woods	: 62,000	: 62,000	: -	: -	: -	: Forest Survey (1938)
Koochiching	: 148,000	: 112,480	: 35,520	: -	: -	: Forest Survey (1938)
Clearwater	: 9,100	: -	: -	: 9,100	: -	: Forest Survey (In Progress)
Beltrami	: 54,000	: 22,140	: 21,600	: 10,260	: -	: Forest Survey (1938)
Hubbard	: 5,000	: -	: -	: -	: 5,000	: Forest Survey (1938)
Wadena	: 2,000	: -	: -	: -	: 2,000	: Forest Survey (1938)
Cass	: 31,900	: -	: 11,484	: 8,932	: 11,484	: Forest Survey (In Progress)
Crow Wing	: 10,400	: -	: -	: 1,872	: 8,528	: Forest Survey (In Progress)
Nitkin	: 39,400	: -	: -	: 23,246	: 16,154	: Forest Survey (In Progress)
Itasca	: 29,000	: -	: 17,980	: 11,020	: -	: Forest Survey (1938)
Carlton	: 3,500	: -	: -	: 3,150	: 350	: Forest Survey (In Progress)

TABLE 1 (continued)

County	: Total Acreage: : of Tamarack : Type*	Estimated Acreage of Tamarack Type in Infestation Zones				: Source of Information
		(Numbers correspond to zones in map 2)				
		1	2	3	4	
Lake and St. Louis	: 39,731	: 27,812	: -	: 11,919	: -	: Superior N. F. Management : Plan (circa 1936) for : Superior N. F. area. For : remainder of St. Louis and : Lake Counties estimates are : based on percent of gross : acreage figure suggested by : headquarters staff of : Superior N. F.
Cook	: 89	: 89	: -	: -	: -	: Based on percent of gross : acreage figure suggested by : headquarters staff of : Superior N. F.
Totals	: 434,120	: 224,521	: 86,584	: 79,499	: 43,516	:

* Tamarack type designation is taken from USDA Forest Service TM Handbook for North Central Region, 1949. Type is so designated if stand is more than 50 percent swamp conifers with tamarack outweighing other species. Estimate is based upon percent of total county area in each infestation zone and assumes that tamarack is homogeneously distributed throughout the county. Such an assumption is, of course, one of the major shortcomings of these data.

** Figures on the Forest Surveys for 1938 and current were supplied by the Lake States Forest Experiment Station Staff.

It is considered desirable to have available other criteria of sawfly abundance apart from defoliation estimates. Such techniques are particularly valuable if it becomes necessary to determine the defoliation potential of a population, or if analysis of the situation must be made in the spring or fall when evidences of feeding are not readily apparent. Traditionally, workers on the larch sawfly have resorted to square foot soil cocoon counts. Since rodents destroy large numbers of cocoons, or disturb the normal distribution of the insect within the soil by caching cocoons, this technique is of questionable value even when made in the fall before such predation is an important factor. Variability in crown size, ground cover (see Figure 3), soil type and proficiency of the technicians also are factors to be considered. In addition, despite employment of considerable bias, one cannot in a limited time such as was devoted to this work, secure enough replications to bring the error within reasonable limits. Preliminary trials of the square foot method served to demonstrate its impracticability from an economic standpoint, which in the last analysis dictates the methods that must be employed.

With these and other considerations in mind it was decided to resort to time collections and attempt a correlation with defoliation estimates. In view of the time available for this work, primary consideration was given to plot distribution, since it was necessary to sample a large area and obtain a representative picture of the infestation pattern throughout the region. When a satisfactory number of plots was decided upon, and travel time considered, it was possible to allow 3 man hours per plot. The two men assigned to this work were obliged to spend half of their time on note-taking and half on cocoon-collecting. Cocoons were collected from underneath at least 10 representative trees, searching being confined to the surface covered by the crown and to a depth dictated by the soil type. In this manner randomization of samplings was achieved within the sampling universe and more productive use of the worker's time was possible, as he was not bound to an arbitrarily selected sampling station which could prove unsuitable because of large roots, water, or mineral soil. Such a practical approach to the problem was doubly desirable because it afforded the best return of cocoons per man hour and procurement of a substantial quantity from each plot was necessary for subsequent parasite abundance determinations.

Figure 4 shows the number of cocoons collected per 90 minute period per man in each of 23 areas where defoliation was noticeable, plotted against estimated percent defoliation. (Estimates within 5 percent based on 10 trees selected at random). These 23 plots represent all the permanent plots in Minnesota, and since defoliation of 1 percent or over was not found in either Michigan or Wisconsin, no collections were attempted in those States. The foregoing figure shows a regression line based upon the calculated regression coefficient of $3.99x$. The correlation coefficient is highly significant, indicating a relationship of numbers to defoliation despite a rather high standard error of estimate. In this work, all collections were made by the same two individuals. Going back to 1949, similar time collections made at 29 points in Minnesota, with contributed assistance of State, County and Forest Service technicians, yielded the results shown in Figure 5. A total of 7 men participated in this work in 1949, only one of whom took part in all 29 collections. Despite this lack of uniformity in personnel, an even better correlation coefficient was forthcoming when the collections were equated to cocoons per man per 90 minute collection. In this latter

Figure 3

Photographs of two extreme types of forest floor encountered in cocoon samplings.



A. Forest floor showing absence of herbaceous and woody plant ground cover.



B. Forest floor showing dense carpet of herbaceous and woody plant ground cover.

FIGURE 4

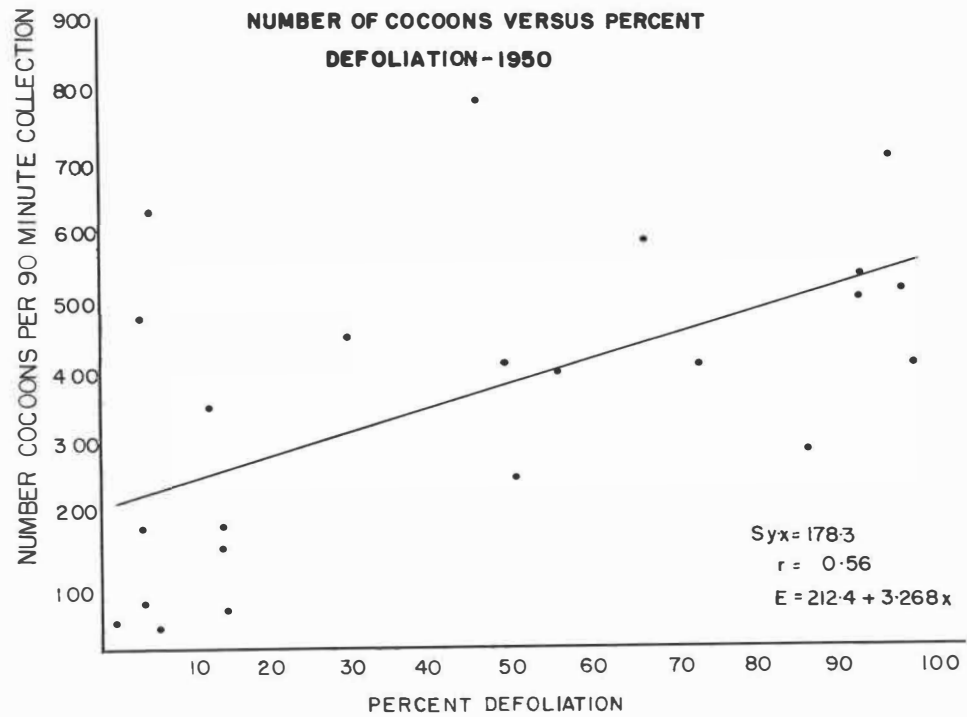
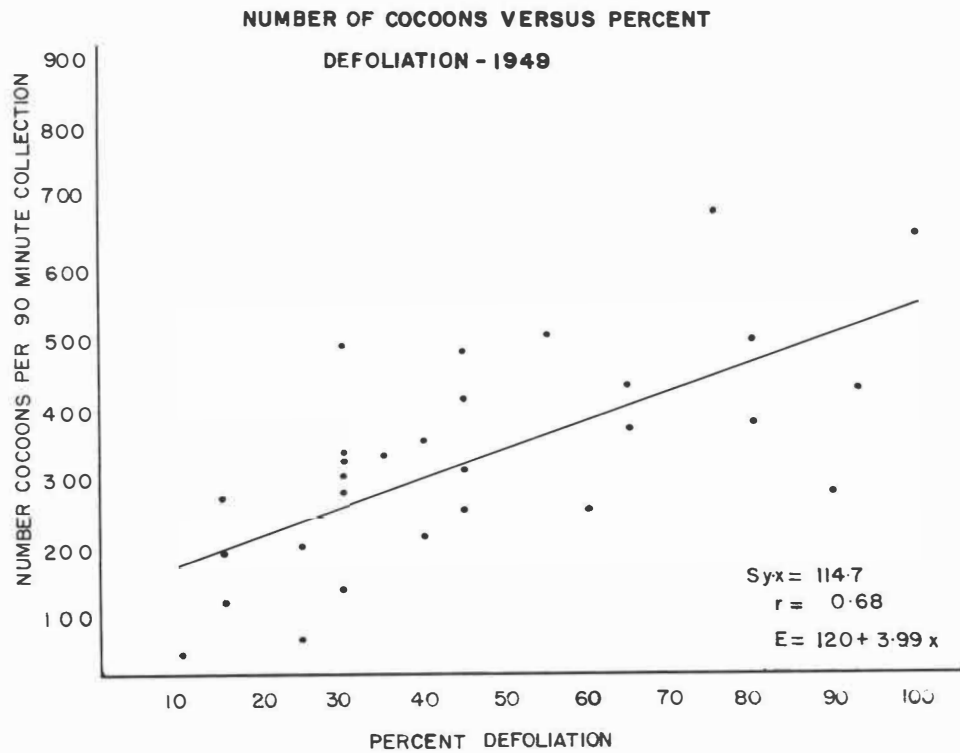


FIGURE 5



instance the correlation coefficient was .68 as compared to .56 for the collections made in 1950.

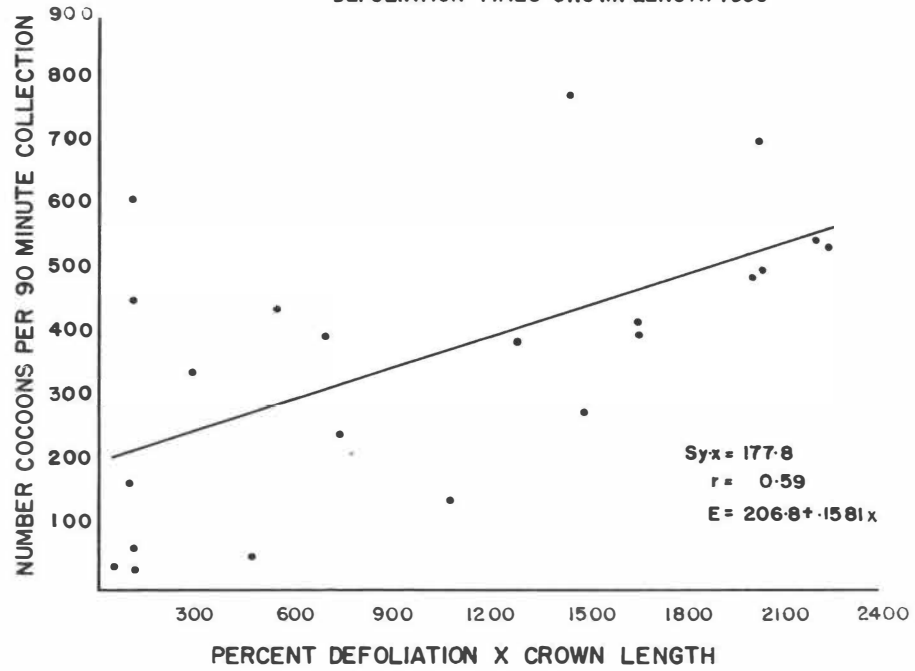
Percent defoliation would not necessarily be indicative of the number of larvae present in a given plot, unless figures were available on the size of the crown. For example, 10 percent defoliation of a crown 20 feet from top to bottom would not yield a larval population directly comparable with 10 percent defoliation of a crown only 10 feet from top to bottom. In order to determine what effect this type of correction for crown volume might have on the standard error of estimate, number of cocoons per 90 minute collection were plotted against the product of crown length (in feet) and percent defoliation. As can be seen in Figure 6 the slope of the regression line does not differ greatly from that where percent defoliation alone was considered. The standard errors of estimate of the two are 178.3 in the latter and 177.8 in the former. Obviously the error lies elsewhere; probably in the method of estimating defoliation, and/or in the differences in the ease with which cocoons are procurable under the various conditions of ground cover. The former method undoubtedly can be considerably refined, but the latter seems less amenable to quantitative expression.

DISCUSSION

The infestation in 1950 can be considered to have declined on the Chippewa National Forest and to have remained static on the Superior National Forest. Despite the failure of the insect to extend the scope of heavy defoliation appreciably, there is no cause for the optimistic belief that populations are declining generally. There is good evidence that high water levels in most of the Chippewa National Forest swamps at the time of cocooning in 1949 severely reduced the populations throughout that Forest. This was brought about by torrential rains in July when rainfall during the first 12 days of the month exceeded the 32-year average for the entire month by 4.49 inches. This is 2.49 inches more than that recorded at Aurora on the Superior for a comparable period, but even if it were not lower on the Superior it must be remembered that seasonal development would be slower on most of the Superior than on the Chippewa in any event. Pending complete analysis of water level data in relation to the cocooning universe, it need only be mentioned that raising the water level 1 inch may diminish the area of water-free forest floor by 10 - 30 percent. This means that dropping larvae (1) have increased chances of drowning immediately by falling into pools, or (2) are more likely to suffocate even if they land in suitable cocooning niches because of an increased likelihood of subsequent immersion. Burbidge and Lejeune (1950) are in possession of evidence that susceptibility to flooding is much higher during the "hardening-off" period than it is after the cocoons are 10 weeks old; tolerance increasing gradually up to that point, when they are able to withstand over 30 days immersion. The fact that high water levels were apparently not as important a factor on the Superior as on the Chippewa does not necessarily refute the possibility that they might have been instrumental in preventing the spread of the epidemic south and southeastward.

FIGURE 6

NUMBER OF COCOONS VERSUS PERCENT
DEFOLIATION TIMES CROWN LENGTH-1950



An important objective of this survey was to obtain information on tree mortality caused by the sawfly. In none of the stands examined was it possible to say unequivocally that the sawfly was responsible for death of any of the trees. At least one area under intensive study suffered heavy defoliation in 1948 and has been under lighter attack since then, but it was not possible to find trees with death attributable to the sawfly in this stand. The probable effects of complete defoliation by this insect over a prolonged period are as yet conjectural, and references in the literature to defoliation paving the way for attacks by bark beetles remain a possibility. The fact is, however, that in one of the two plots where Dendroctonus simplex (Lec.) injury was found this year (opposite Upper Red Lake) there is reason to doubt that this insect is attacking any but trees in the last stages of decline (Figure 7). In this stand also, approximately 20 percent of the trees showed heart-rot; the same percentage as was attacked by bark beetles. This particular stand appears to be declining because of other reasons - notably modification of site evidenced by the influx of a luxuriant woody undergrowth, and increased competition between the overmature tamarack and other tree species. The stand itself is considerably older than the rest of the tamarack throughout the region. At another stand near Bagley, Minnesota alleged tree mortality was not confirmed because State Foresters had removed unthrifty trees before it was brought to the attention of entomologists. Dendroctonus injury to a pocket of perhaps a dozen trees at the point of a wind-throw was noted here, but the attack was not general throughout the stand, despite a history of previous heavy sawfly attack apparent from oviposition scars. At the present time it is not possible to ascribe any tree mortality to sawfly attack, but this picture is confused by the recession of infestations on the Chippewa in 1950 where the stands were under closer observation. Many extensive areas on the Superior are now known to have sustained complete defoliation 2 years running, and barring a cataclysmic decline of sawfly populations, the mortality picture conceivably could be altered next year. Reduced increment undoubtedly has occurred in many stands, and while sections are on hand for analysis, the results will have to be presented later in an annual progress report covering research activities.

RECOMMENDED COURSE OF ACTION

As long as there is no significant tree mortality, loss of increment in itself cannot be considered justification for expenditure of funds on direct control of this insect. This derives not as much from the current economic value of most of the tamarack in the Lake States as from the physical difficulties inherent in any such control operation. The evidence obtained from experimental spraying of several areas with DDT at the rate of 1 pound DDT per gallon of fuel oil per acre is promising enough to suggest that the insect populations in a given area can be significantly reduced if necessary. By virtue of the general distribution of tamarack throughout extensive areas as small pockets or as a minor component in mixed stands, the cost per acre is considerably higher than it would be if a greater number of infested trees were present per acre, or if they occurred in larger more nearly pure stands. The likelihood of reinfestation of treated areas is much greater under existing circumstances, also. Since Forest Service tamarack holdings are small by comparison with those of state and county agencies, particularly in Minnesota, action programs designed for controlling the insect over extensive areas are further complicated.

Figure 7
Photographs of Upper Red Lake Plot.



A. Roadside view of trees in Upper Red Lake Plot.



B. Dendroctonus simplex Lec. work on tamarack in Upper Red Lake plot. Note dense woody undergrowth.

At the present time it is felt that direct control measures should not be contemplated unless mortality within a particular stand makes it imperative that the pressure be relieved, assuming that the stand itself is of sufficient value. If this condition becomes general throughout the infested area, further selection should be made on the basis of the probable consequences of tamarack mortality. If there is an appreciable component of other tree species, the stand should be given a low priority. Area spraying, in view of the extreme variability of tamarack site and in the quality of stands, plus the many difficulties stemming from its implementation, seems out of the question.

CONCLUSIONS

The survey work begun in 1949 and elaborated upon in 1950 should be intensified in 1951 with emphasis being placed on those areas where the history of previous defoliation might suggest possible tree mortality. In addition, more attention will have to be given to those trees in Area 3 (Figure 2) which are as yet not significantly affected by the sawfly.

There should be no relaxation of the survey program despite the failure of the epidemic to extend its boundaries in 1950. On the contrary, the extremely favorable conditions for sawfly development which occurred last season over most of Minnesota are ample justification for fears that the outbreak may well reach a new peak of intensity if it does not in fact become more generally prevalent throughout those portions of tamarack range which have so far escaped injury.

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APPENDIX

DETAILED DESCRIPTIONS OF PERMANENT ROADSIDE OBSERVATION PLOTS

Plot Number	Location	Number Cocoons 1-1/2 man hours	Estimated Percent Defoliation
<u>MINNESOTA</u>			
1	7 mi. West of Warroad on Hwy. 11; turn North 2.8 mi.; turn East 1.5 mi.	167	15.5
2	7.4 mi. South of Spooner on Hwy. 72 - west side	346	13.0
3	32.2 mi. South of Spooner on Hwy. 72 - east side	365	49.0
4	0.9 mi. West of Hines on Balsam Beach Rd.	462	5.5
5	0.4 mi. South of Dixon Lake L. O. - then 5 miles North of Section line	39	1.5
6	8.5 mi. East of Walker on Hwy. 34 - north side of road	31	6.5
7	5.1 mi. North of Hwy. 34 on road to Fed. Dam - east side of road	70	5.5
8	2.1 mi. North of Deer River C. L. on Hwy. 6 - east side	614	6.0
9	18.7 mi. North of Deer River C. L. on Hwy. 6 - east side	172	6.6
10	1.5 mi. South of Cusson - east side of road	280	87.0
11	3.3 mi. South of Jct. Co. Rd. 1 - St. Rd. 53 via 1 - 24 - 540	561	66.5
12	3.9 mi. North of Hwy. 169 on Co. Rd. 303 and 68 - east side	776	47.5
13	3.9 mi. Northeast of Aurora C. L. on Hwy. 35	505	98.0
14	1.6 mi. Northeast of Embarrass on north side Co. Hwy. 21	420	100.0
15	3.2 mi. South of Ely on S. A. R. 21 - east side	525	93.0
16	7.7 mi. West of S. A. R. No. 2 on Co. Rd. 11 - east side	703	95.5
17	5.2 mi. North of Toimi Rd. on asphalt road to Ely - west side	246	51.5
18	3.3 mi. North of Hwy. 1 on road 3.6 miles West of Isabella - east side	488	93.0
19	10.1 mi. North of Finland C. L. on Hwy. 1	396	73.5
20	2.0 mi. North of Tofto-Isabella Jct. - west side	384	56.5
21	5.2 mi. North of CCC Camp on Sawbill Trail - west side	441	30.5
22	1.1 mi. West of Gunflint Lodge - turn off north side of Trail	50	16.9
23	11.5 mi. North of Grand Marais on Gunflint Trail	147	

APPENDIX

DETAILED DESCRIPTIONS OF PERMANENT ROADSIDE OBSERVATION PLOTS (Continued)

Plot Number	Location	Number Cocoons 1-1/2 man hours	Estimated Percent Defoliation
<u>WISCONSIN</u>			
24	4.8 mi. West of Brule C. L. on south side of road	12	- 1
25	4.4 mi. North of Haugen on Hwy. 53	0	0
26	0.7 mi. South of Fifield on Hwy. 13 - west side	0	0
27	3.9 mi. South of Lakewood on Hwy. 32 - east side	0	0
<u>MICHIGAN</u>			
28	3.2 mi. East of Ironwood on M-28; south 2 miles (east side of road)	0	0
29	4.6 mi. East of Jct. M-28 and U. S. 41 on U. S. 41	0	0
30	0.9 mi. East of Co. Rd. 513 on U. S. 2	0	0
31	4.5 mi. North of Adams Trail on east side of road	0	0
32	1.6 mi. North of R. R. on M-123 - west side of road	0	0
33	0.7 mi. East of turn in road at Hessel on M-134	0	0
34	0.8 mi. West of Tower on M-68 - south side	0	0
35	1.5 mi. in from Oscoda Monument Road on Henegers Road (turns off Monument Road 2.3 miles east of Monument)	0	0
36	0.5 mi. West of L. Mitchell Road on Moon Road	0	0

SURVEY SHEET - LARCH SAWFLY

Plot No.: 16

1. Date: 8/27/50 Observers: Butcher - Feigal Trees per acre: 1220
2.0 mi. N. of Deer River

2. Location: T. 145 Range: 25 Sec. 23 Description: D. L. on Hwy. 6 - E. side

3. Acreage: 100 ± Comp.: Tamarack 50 %; Spruce 5 %; Cedar 20 %; Other 25 %

4. Tree: 1 2 3 4 5 6 7 8 9 10 Average

DBH (Inches): 6 4 3 4 4 4 6 4 6 4 4.5

Total Ht. (Ft.): 45 45 30 35 40 40 35 35 40 40 38.5

Cr. Ht. (Ft.): 25 15 10 10 15 15 20 15 18 15 15.8

Defol. (Percent): 5 10 0 5 0 0 5 10 10 15 6.0

Bark Beetle: None

Borers: None

Percent samp-
ling universe
under H₂O: None

*Oviposition -
1949: L L L L L L L L L L

1950: L L A L A H L L L L

5-a. Undergrowth (species present, abundance, etc.): Negligible

b. Ground cover (species present, percent of surface occupied, etc.):
Needles 50 percent; sphagnum 50 percent

c. Topography of swamp (down trees; physiographic features, etc.): Very rough;
up to 24-inch vertical differential. Light slash (mostly cedar).

6. No. of rings per last inch: _____

7. Additional notes: Dead trees present in center of the pothole. Above
samplings made on swamp periphery.

* L - Light

M - Moderate

H - Heavy

A - Absent